LOCATION ESTIMATION SYSTEM

CROSS REFERENCE TO RELATED APPLICATIONS

The present application claims priority to and incorporates by reference a provisional application having a serial number of 62/180,596 filed on Jun. 16, 2015 and a provisional application having a serial number of 62/296,109 filed on Feb. 17, 2016, both of which have a title of LOCATION ESTIMATION SYSTEM and are by the current Inventor.

BACKGROUND

1. Technical Field

The present invention relates to location estimation systems and, more specifically, to location estimation systems that incorporate triangulation techniques to determine a location.

2. Related Art

Location estimation devices exist for all types of sports, navigation, and asset tracking systems. Golf, for example, is well known for having many location estimation devices that utilize GPS and/or telescoping systems in a sometimes-futile attempt to help the golfer place the ball close to the pin. GPS systems are also used for automotive and other outdoor navigational systems. Initially, GPS was developed for military applications. Casual users, such as sailors, were required to use other less accurate technologies such as the sextant or, more recently, Loran to navigate their way across a body of water. Eventually, GPS technology was made accessible to the public but with a reduced accuracy. Recently, however, GPS systems have been allowed to be made public that have sufficiently higher levels of accuracy. The accuracy of a GPS system may be within a few meters of the indicated location. As such, GPS receivers are now common in navigation systems, cell phones, and even watches.

One problem with GPS receivers, however, is that GPS signals that allow the receiver to triangulate the receiver's location often do not reach receivers that are within a structure. As such, other technologies such as accelerometers and magnetometers are used to supplement GPS data to generate estimates of the location in place of the GPS data. Such systems, however, very rapidly become highly inaccurate thereby effectively terminating location estimation functionality after even a short period of time. Generally, a need exists for a location estimation system that maintains positional accuracy even within structures such as office buildings, warehouses and hospitals.

BRIEF SUMMARY OF THE INVENTION

The present invention is directed to apparatus and methods of operation that are further described in the following Brief Description of the Drawings, the Detailed Description of the Invention, and the claims. Other features and advantages of the present invention will become apparent from the following detailed description of the invention made with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

A better understanding of the present invention can be obtained when the following detailed description of the preferred embodiment is considered with the following drawings, in which:

FIG. **1** is a block diagram that illustrates a location determination system according to one embodiment.

FIG. **2** is a block diagram that illustrates an ultra wide-band position determination system.

FIG. **3** is a block diagram that illustrates an ultra wide-band position determination system.

FIG. **4** is a table that illustrates a channel configuration chart according to a communication standard utilized in one embodiment.

FIG. **5** is a block diagram that illustrates TOA (time of arrival) algorithm according to one embodiment.

FIG. **6** is a block diagram that illustrates operation of an automatic anchor location determination algorithm by a plurality of anchors according to one embodiment.

FIG. **7** is a block diagram that illustrates operation of a trilateration algorithm by a plurality of anchors according to one embodiment.

FIG. **8** is a block diagram that illustrates operation of an altitude algorithm according to one embodiment.

FIG. **9** is a functional block diagram that illustrates a location determination processing block that includes a plurality of Kalman filters according to one embodiment that utilizes the various values derived by circuitry as described above.

FIG. **10** is a diagram used to illustrate a 3 Dimensional (3D) Auto Anchor Location Algorithm according to one embodiment.

FIG. **11** is a block diagram that illustrates a method for a 3D Trilateration Algorithm.

FIG. **12** is a diagram used to illustrate a 3 Dimensional (3D) Trilateration Algorithm according to one embodiment.

FIG. **13** is a functional block diagram of a system according to one embodiment that illustrates operation.

FIG. **14** illustrates a method for estimating a location according to one embodiment of the invention.

FIG. **15** is a flow chart that illustrates a method for determining a tag/processor device location according to one embodiment.

FIG. **16** is a functional block diagram of a tag/processor device according to one embodiment.

FIG. **17** is a functional block diagram of an anchor in a location determination system that comprises a plurality of anchors and a tag/processor device according to one embodiment.

FIG. **18** is a functional block diagram of a computer readable media containing computer instructions that defines operational logic for a processor of a location determination tag/processor according to one embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

FIG. **1** is a block diagram that illustrates a location determination system according to one embodiment. More specifically, FIG. **1** illustrates one embodiment of a high speed Kalman tracking (HSKT™) location determination device **10** that includes a plurality of sensor types whose data is processed by a processor **12** to determine location with a high degree of accurate resolution. Location determination device **10** is referenced herein as a tag/processor device **10**. Processor **12** is a general purpose or application specific processor configured to operate as a high speed Kalman tracking device that Kalman filters received data from a plurality of sensors to determine precise location information. A memory **13** is coupled to deliver computer instructions to processor **12** for execution. The computer instructions are configured to cause processor **12** to perform the